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(84) Stabilized antifreeze/coolant composition containing borate and silicate corrosion inhibitors.

(57) A corrosion-inhibited and stabilized liquid alcohol antifreeze/coolant composition comprising alkali metal borate and alkali metal silicate corrosion inhibitors and at least one precipitation-inhibiting stabilizer selected from the group consisting of: hydrocarbyl aminophosphonic acids, phosphino polycarboxylic acids, polyacrylic acids, and/or the alkali metal salts thereof is described. Ordinarily, insoluble alkali earth metal silicate precipitates detrimental to engine cooling systems tend to form when antifreeze/coolant formulations containing alkali metal borate and silicate corrosion inhibiting compounds are diluted with hard water. However, the stabilized antifreeze/coolant composition of the instant invention resists and inhibits the formation of such insoluble precipitates when diluted with hard water.

EP 0 245 557 A2

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**STABILIZED ANTIFREEZE/COOLANT COMPOSITION CONTAINING BORATE AND SILICATE CORROSION INHIBITORS**

This invention is directed to antifreeze/coolant concentrate formulations containing alkali metal borate and silicate corrosion inhibitors and precipitation-inhibiting stabilizers, and to aqueous antifreeze/coolant formulations containing alkali metal borate and silicate corrosion inhibitors and precipitation-inhibiting stabilizers. More particularly, this invention relates to alkali metal borate and silicate-containing water soluble liquid alcohol antifreeze/coolant compositions additionally containing at least one precipitation-inhibiting stabilizer, where said stabilizer is selected from the group comprising: hydrocarbyl aminophosphonic acids and/or the alkali metal salts of said acids; phosphino polycarboxylic acids and/or the alkali metal salts of said acids; and polyacrylic acids and/or the alkali metal salts of said acids. These stabilizers are particularly useful in preventing the precipitation of insoluble alkali earth metal silicate floc materials from antifreeze/coolant formulations containing alkali metal borate and silicate corrosion-inhibiting compounds, where said formulations are diluted with hard water.

Automobile engine cooling systems contain a variety of metals, including copper, solder, brass, steel, cast iron, and aluminum. The possibility of corrosive attack on such metals is high, due to the presence of various ions as well as the high temperatures, pressures, and flow rates found in such cooling systems. The presence of corrosion products within the cooling system can interfere with heat transfer from the engine combustion chambers, and may subsequently cause engine overheating and engine component failure due to excess metal temperatures. To prevent these problems, a variety of organic and inorganic compositions have been employed as corrosion inhibitors in engine antifreeze/coolant formulations, including various borate and silicate compounds. See generally Fay, R. H., "Antifreezes and Deicing Fluids," in: Kirk-Othmer Encyclopedia of Chemical Technology (1978 ed.), vol. 3, pp. 79-95.

Antifreeze/coolant concentrate formulations are typically diluted with water prior to use in automobile engine cooling systems. However, in many areas only hard water is available to dilute the antifreeze/coolant formulation. Hardness of water is a function of the concentration of dissolved calcium and magnesium salts contained in the water, and is usually expressed in terms of a concentration (ppm) as  $\text{CaCO}_3$  Total Hardness. Hard water is defined herein as water with greater than 150 ppm as  $\text{CaCO}_3$  Total Hardness.

It has been observed that the use of hard water to dilute antifreeze/coolant formulation which contain alkali metal silicate and borate corrosion inhibitors causes the formation of insoluble alkali earth metal silicate flocs which precipitate from the antifreeze-water solution. These insoluble silicate flocs are primarily calcium and/or magnesium silicate salts, and have an adverse effect on the antifreeze/coolant formulation and engine cooling system for two reasons. First, since the precipitates are alkali earth metal silicate flocs, a rapid depletion of silicate in solution occurs; thus the corrosion-inhibiting properties of the formulation are depleted. Second, the precipitating solids will scale and eventually plug the passages of the engine cooling system. This will interfere with heat transfer from the engine combustion chambers, and subsequently may cause engine overheating and engine component failure due to excess metal temperatures.

It would thus be advantageous if the precipitation of insoluble alkali earth metal silicate flocs in antifreeze/coolant concentrate formulations containing alkali metal borate and silicate corrosion inhibitors which are diluted with hard water could be controlled or eliminated. It is the object of the instant invention to provide a stabilized antifreeze/coolant concentrate formulation containing alkali metal silicate and borate corrosion inhibitors which will resist the formation and precipitation of such insoluble silicate floc materials when hard water is employed to dilute said antifreeze/coolant concentrate formulations.

The instant invention discloses the use of aminophosphonic acid/aminophosphonate, phosphino polycarboxylic acid/polycarboxylate, and/or polyacrylic acid/polyacrylate compositions, or mixtures thereof, as stabilizers to prevent the precipitation of insoluble alkali earth metal silicate floc materials in antifreeze/coolant concentrate formulations containing borate and silicate corrosion inhibitors, where said formulations are diluted with hard water. References which describe uses of similar compounds are as follows:

U.S. Pat. No. 4,387,027 discloses a method of inhibiting corrosion and controlling deposition in iron-containing aqueous systems by the addition of 6-30 ppm a water soluble orthophosphate in combination with 3-25 ppm of a water soluble acrylic acid/salt or a water soluble hydroxy alkylacrylate copolymer;

U.S. Pat. No. 4,333,843 discloses a gelation resistant aqueous glycol composition comprising an effective amount of an alkali metal silicate to reduce corrosion and an effective amount of an organophosphorous-silicon compound



wherein R is a C<sub>1</sub>-C<sub>4</sub> alkyl group and n is an integer of 1-4;

0 245 557

U.S. Pat. No. 4,329,243 discloses a cavitation-inhibiting, cooling and/or heat-transfer liquid comprising a glycol, a conventional corrosion inhibitor, and a phosphonic acid which may contain phenylene, a C<sub>1</sub>-C<sub>6</sub> alkylene, or such groups substituted by hydroxy, amino, PO<sub>3</sub>H<sub>2</sub>, or polyamino/polyalkylene groups;

U.S. Pat. No. 4,328,180 discloses a method of inhibiting corrosion and controlling deposition of calciferous scale in cooling water systems by the addition of 0.3-3.0 ppm polyacrylic acid, 0.1-1.0 ppm tartaric acid, 0.1-2.0 ppm sodium sulfonate dispersant, 0.1-1.0 ppm of a mixture of organic phosphonates, 0.5-3.0 ppm phosphate ester dispersant, 3-40 ppm inorganic phosphate, and 0.1-10 ppm aromatic triazole;

U.S. Pat. No. 4,320,025 discloses a cavitation-inhibiting, non-freezing, cooling and/or heat transfer liquid comprising water, a glycol, and 0.005-0.2 wt.% of at least one phosphono carboxylic acid containing at least two carboxylic acid groups;

U.S. Pat. No. 4,320,023 discloses an antifreeze formulation containing ethylene glycol and 50-500 ppm of an alkylene diphosphonic acid which is useful in retarding precipitation of aluminum corrosion products in engine cooling systems;

U.S. Pat. No. 4,277,359 discloses a scale and corrosion inhibitor for use in aqueous systems comprising a water soluble polyacrylic acid with a molecular weight ranging up to about 2500, a phosphorous acid and its salts, and a carboxylic acid chelate having at least one hydroxyl substituent;

U.S. Pat. No. 4,076,501 discloses a corrosion inhibitor for use in aqueous systems which comprises the use of an aminophosphonic acid, where said aminophosphonic acid contains a R<sub>1</sub>-N bond, R<sub>1</sub> being a straight chain C<sub>1</sub>-C<sub>6</sub> alkyl group, a C<sub>3</sub>-C<sub>6</sub> alkenyl group with the double bond not adjacent to N, a tolyl group, a benzyl group, or a cyclohexyl group;

U.S. Pat. No. 3,980,576 discloses a scale and corrosion inhibitor for use in aqueous systems comprising a water-soluble alkaline oxide silicate, an organic phosphonate, and a carboxy methyl cellulose;

U.S. Pat. No. 3,948,792 discloses a corrosion inhibiting and scale reducing/softening composition for use in automobile and diesel engine coolant systems where a silicate containing anti-corrosion formula is used, comprising the silicate containing anti-corrosion formula in combination with an effective amount of a polymeric dispersant which is a water soluble polycarboxylic acid employed in an amount of 0.1-10 wt. % of the formula, with an average molecular weight in the range of 1,000 - 1,000,000;

U.S. Pat. No. 3,837,803 discloses a corrosion inhibiting composition for use in aqueous systems containing solubilized calcium salts comprising a water soluble organic or inorganic orthophosphate in combination with a water-soluble organophosphonic acid or salt thereof;

U.S. Pat. No. 3,663,448 discloses a composition useful for inhibiting alkaline earth metal scale deposition in aqueous systems comprising about one part by weight of an aminophosphonate, and from about 0.5 to 5 parts by weight of a water soluble polyacrylic acid or polyacrylamide having a molecular weight in the range of 500-12,000; and

API Oilfield Chemicals Abstract, vol. 29, paragraph F1173 (Oct. 1982) describes German Patent DE 3,044,214, which discloses the use of a phosphono-polycarboxylic acid containing unsaturated monocarboxylic and dicarboxylic acid units for use in aqueous systems to inhibit inorganic material scale formation and precipitation.

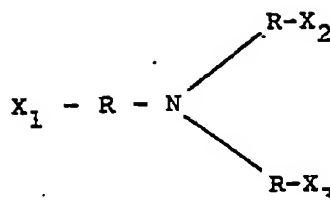
The instant invention is directed to a novel precipitation-resistant antifreeze/coolant concentrate composition containing alkali metal silicate and borate corrosion inhibitors, and to aqueous antifreeze/coolant compositions where said concentrate is diluted with hard water (defined herein as water of greater than 150 ppm as CaCO<sub>3</sub> Total Hardness). It has been discovered that the stabilized and corrosion-inhibited antifreeze/coolant concentrate of the instant invention, when diluted with hard water, remains a stable composition in which the precipitation of insoluble alkali earth metal silicate floc material detrimental to the cooling systems of internal combustion engines is inhibited.

The antifreeze/coolant concentrate composition of the instant invention comprises 80-99 wt.%, preferably 80-99 wt.% of a water soluble liquid alcohol freezing point depressant, preferably ethylene glycol, 0.1-10.0 wt.%, preferably 0.5-5.0 wt. % of an alkali metal borate corrosion inhibitor such as sodium metaborate pentahydrate, 0.1-1.0 wt.%, preferably 0.15-0.5 wt.% of an alkali metal silicate corrosion inhibitor such as sodium metasilicate pentahydrate, and 100-10,000 ppm, preferably 100-5000 ppm of at least one precipitation-inhibiting stabilizer selected from the group consisting of:

(i) a hydrocarbyl aminophosphonic acid and/or alkali metal aminophosphonate salt or a mixture thereof, said hydrocarbyl aminophosphonic acid having the formula

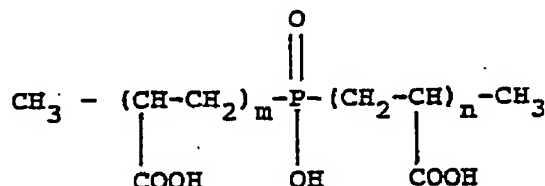
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where R is a substituted or unsubstituted C<sub>1</sub>-C<sub>12</sub> alkylene radical, X<sub>1</sub> is H, OH, PO(OH)<sub>2</sub>, NH<sub>2</sub>, or N[R-PO(OH)<sub>2</sub>]<sub>n</sub>, and X<sub>2</sub> and X<sub>3</sub> are N[R-PO(OH)<sub>2</sub>]<sub>n</sub> or PO(OH)<sub>2</sub>.

(ii) a phosphino polycarboxylic acid and/or alkali metal phosphino polycarboxylate salt or a mixture thereof, said phosphino polycarboxylic acid having a molecular weight range of 200-2000, preferably 300-1500, and having the formula



where m + n has a value from about 2-20, preferably from about 4-16; and

(iii) a polyacrylic acid and/or alkali metal polyacrylate salt or a mixture thereof, said polyacrylic acid having a molecular weight range of 1000-10,000, preferably 500-6000.

The aqueous corrosion-inhibited and precipitation-resistant antifreeze/coolant composition of the instant invention comprises the above-described antifreeze/coolant concentrate composition diluted with 10-90 wt.%, preferably 25-75 wt.% of hard water. This aqueous antifreeze/coolant composition shows improved stability as compared with antifreeze/coolant compositions containing silicate and borate corrosion inhibitors which do not contain any of the above-described precipitation-inhibiting stabilizers.

The novel antifreeze/coolant concentrate composition of the instant invention comprises a liquid alcohol freezing point depressant, an alkali metal borate corrosion inhibitor, an alkali metal silicate corrosion inhibitor, and at least one precipitation-inhibiting stabilizer which may be a hydrocarbyl aminophosphonic acid and/or alkali metal aminophosphate salt or mixture thereof, a phosphino polycarboxylic acid and/or alkali metal phosphino polycarboxylate salt or mixture thereof, or a polyacrylic acid and/or alkali metal polyacrylate salt, or mixture thereof.

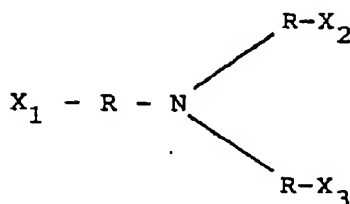
The liquid alcohol freezing point depressant component of the above-described antifreeze/coolant concentrate composition may be a glycol or glycol ether. The glycol ethers which may be employed as major components in the instant invention include glycols such as ethylene glycol, diethylene glycol, propylene glycol, dipropylene glycol, and glycol monoethers such as the methyl, ethyl, propyl, and butyl ethers of ethylene glycol, diethylene glycol, propylene glycol, and dipropylene glycol. The liquid alcohol freezing point depressant component may be employed in concentrations of 80% to 99% by weight, preferably 90% to 99% by weight. Ethylene glycol is particularly preferred as the liquid alcohol freezing point depressant component.

The alkali metal borate corrosion-inhibiting component of the above-described antifreeze/coolant concentrate composition may be any alkali metal borate compound employed in admixture with the above-described liquid alcohol freezing point depressant. The alkali metal borate corrosion-inhibiting component may be employed in concentrations of 0.1 - 10.0 wt. %, preferably 0.5-5.0 wt.%. Sodium metaborate pentahydrate is particularly preferred.

The corrosion-inhibiting silicate component of the above-described antifreeze/coolant concentrate composition may be any alkali metal silicate compound employed in admixture with the above-described liquid alcohol freezing point depressant. The alkali metal silicate corrosion-inhibiting component may be employed in concentrations of 0.1-1.0 wt.%, preferably 0.15-0.5 wt.%. Sodium metasilicate pentahydrate is particularly preferred. Organosilane silicate stabilizers may additionally be employed in concentrations of 0.01-1.0 wt.%.

The hydrocarbyl aminophosphonic acid stabilizer component of the above-described antifreeze/coolant concentrate composition may be represented by the formula:

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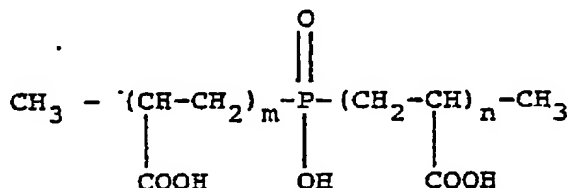


where R is a substituted or unsubstituted C<sub>1</sub>-C<sub>12</sub> alkylene radical, X<sub>1</sub> is H, OH, PO(OH)<sub>2</sub>, NH<sub>2</sub>, or N[R-PO(OH)<sub>2</sub>], and X<sub>2</sub> and X<sub>3</sub> are N[R-PO(OH)<sub>2</sub>]<sub>2</sub> or PO(OH)<sub>2</sub>. Examples of hydrocarbyl aminophosphonic acids suitable for use as precipitation-inhibiting stabilizers in the instant invention include:

diethylenetriamine pentakis(methylenephosphonic acid);  
 ethylenediamine tetra(methylenephosphonic acid);  
 N-(hydroxyethyl)-N-bis (methylenephosphonic acid);  
 hexamethylenediamine - N,N,N',N' -tetra(methylenephosphonic acid); and  
 nitrilo tris(methylenephosphonic acid).

Alkali metal aminophosphonates derived from the above-described aminophosphonic acid may also be employed in the antifreeze/coolant composition of the instant invention. Sodium aminophosphonates are particularly preferred. Aminophosphonic acids and aminophosphonates suitable for use include those commercially available from Wayland Chemical Co. under the Wayplex Series trade name, such as Wayplex 45K (ethylenediamine - N,N,N',N' -tetra(methylenephosphonic acid)), and those available from Albright & Wilson (a Tenneco Company) under the Briquest Series trade name, such as Briquest 543-33S (sodium diethylenetriamine pentakis-(methylenephosphonate)). The approximate concentrations of the above-described hydrocarbyl aminophosphonic acids and/or aminophosphonates or mixtures thereof which may be employed in the antifreeze/coolant composition of the instant invention are about 100 ppm-10,000 ppm, preferably about 100 ppm-5000 ppm.

The phosphino polycarboxylic acid component of the above-described antifreeze/coolant composition may be represented by the formula:



where m + n has a value from about 2-20, preferably from about 4-16. Molecular weights for said phosphino polycarboxylic acid are in the range of 200-2000, preferably 300-1500. Alkali metal phosphino polycarboxylates derived from the above-described phosphino polycarboxylic acid may also be employed in the antifreeze/coolant composition of the instant invention. Sodium phosphino polycarboxylates are particularly preferred. Said acids and/or salts may be present in a concentration range of 100-10,000 ppm, preferably 100-5000 ppm. Phosphino polycarboxylic acids and polycarboxylates suitable for use include those commercially available from Ciba-Gelgy Corp. under the Belsperse and Belclene series trade names, such as Belsperse 161 and Belclene 500.

The polyacrylic acid and/or alkali metal polyacrylate salt stabilizer component of the instant invention is preferably a polyacrylic acid and/or polyacrylate with a molecular weight in the range of about 1000-10,000, preferably from about 500-6000. Sodium polyacrylates are particularly preferred for use in the instant invention. Sodium polyacrylates suitable for use include those commercially available from B. F. Goodrich Company under the Good-rite series trade name, such as Good-rite K-732, K-739, K-752, and K-759. The approximate concentrations of the above-described polyacrylic acid and/or polyacrylate which may be employed in the instant invention are about 100 ppm-10,000 ppm, preferably about 100-5000 ppm.

0 245 557

A preferred additional corrosion inhibitor for use in the instant invention is a hydrocarbyl azole, preferably an aromatic triazole or alkyl-substituted aromatic triazole, such as benzotriazole or tolyltriazole, or a thiazole such as sodium mercaptobenzothiazole. The most preferred azole for use is tolyltriazole. The approximate concentration of the hydrocarbyl azole component which may be employed in the antifreeze/coolant composition of the instant invention is about 0.1 to 0.5 wt. %, preferably about 0.1 to 0.3 wt. %.

One or more conventional corrosion inhibitors may also be employed in the above-described antifreeze/coolant formulation. Such conventional corrosion inhibitors may be employed at concentrations of 0.01-5.0 wt. %, and may be selected from the group comprising: alkali metal hydroxides, alkali metal benzoates, alkali metal nitrates, alkali metal nitrites, and alkali metal molybdates.

In one embodiment of the instant invention, the above-described antifreeze/coolant concentrate composition is diluted with 10% to 90%, preferably 25% to 75% by weight of hard water, defined herein as water with a concentration of greater than 150 ppm as CaCO<sub>3</sub> Total Hardness. The stabilizer component of the above-described antifreeze/coolant composition acts to prevent the silicate corrosion inhibitor contained within the aqueous antifreeze/coolant formulation from forming an insoluble precipitate with alkali earth metal ions (particularly calcium or magnesium ions) introduced into the antifreeze coolant composition via the hard water.

The method of the instant invention will be further illustrated by the following examples, which are not intended to limit the invention, but rather to illuminate it.

#### EXAMPLE 1

An antifreeze concentrate formulation was prepared comprising 94.2 wt.% ethylene glycol, 1.0 wt.% sodium metaborate pentahydrate, 0.47 wt.% of a 50% aqueous solution of sodium hydroxide, 2.0 wt.% of sodium benzoate, .04 wt.% sodium metasilicate pentahydrate, 0.2 wt.% sodium molybdate dihydrate, 0.03 wt.% of an organosilane silicate stabilizer, 0.1 wt.% tolyltriazole, 0.2 wt.% of a 50% aqueous solution of sodium mercaptobenzothiazole, and 1.4 wt.% water.

#### EXAMPLE 2

To the antifreeze concentrate formulation of Example 1, 900 ppm of the aminophosphonate stabilizer sodium diethylenetriamine pentakis(methylenephosphonate) (Briquest 543-33S) was added.

#### EXAMPLE 3

To the antifreeze concentrate formulation of Example 1, 5000 ppm of a phosphino polycarboxylic acid stabilizer of approximate molecular weight 350 (Beldene 500) was added.

#### EXAMPLE 4

To the antifreeze concentrate formulation of Example 1, 3000 ppm of a phosphino polycarboxylic acid stabilizer of approximate molecular weight 1200 (Belsperse 161) was added.

#### EXAMPLE 5

To the antifreeze concentrate formulation of Example 1, 2000 ppm of a sodium polyacrylate stabilizer of approximate molecular weight 5100 (Good-rite K-739) was added.

EXAMPLE 6

An antifreeze concentrate formulation was prepared comprising 93.9 wt.% ethylene glycol, 1.0 wt.% sodium metaborate pentahydrate, 0.24 wt.% of a 50% aqueous solution of sodium hydroxide, 3.0 wt.% sodium benzoate, 0.2 wt.% sodium nitrate, 0.1 wt.% sodium molybdate dihydrate, 0.02 wt.% of an organosilane silicate stabilizer, 0.2 wt.% tolyltriazole, and 1.0 wt.% water.

EXAMPLE 7

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To the antifreeze concentrate formulation of Example 6, 100 ppm of the aminophosphonate stabilizer sodium diethylenetriamine pentakis(methylenephosphonate) (Briquest 543-33S) was added.

16 EXAMPLE 8

To the antifreeze concentrate of Example 6, 100 ppm of the sodium aminophosphonate stabilizer sodium diethylenetriamine pentakis(methylenephosphonate) (Briquest 543-33S) and 50 ppm of a sodium polyacrylate stabilizer of approximate molecular weight 5100 (Good-rite K-739) was added.

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EXAMPLE 9

To the antifreeze concentrate of Example 6, 100 ppm of the sodium aminophosphonate stabilizer sodium diethylenetriamine pentakis(methylenephosphonate) (Briquest 543-33S) and 100 ppm of a sodium polyacrylate stabilizer of approximate molecular weight 5100 (Good-rite K-739) was added.

Examples 1-5 were tested for their stability after dilution with hard water by employing Hard Water Compatibility Test A, described as follows: 100 ml of the antifreeze concentrate to be tested was placed in a 250 ml beaker together with 100 ml of hard water of about 250 ppm as CaCO<sub>3</sub> Total Hardness. This mixture was heated to 90°C for ten minutes, then cooled to room temperature and stored in a dark cabinet for 7 days. Thereafter, any alkali earth metal silicate floc which had precipitated from solution was removed by filtration. A sample of the filtered coolant and a preliminary sample of the coolant obtained prior to the test were both submitted for atomic absorption analysis to determine the percentage of silicate left in solution after the test was completed. Table I sets forth the results of Hard Water Compatibility Test A for Examples 1-5.

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TABLE I

## 5 RESULTS OF HARD WATER COMPATIBILITY TEST A

10 <u>Example</u>	<u>Stabilizer Additive (ppm)</u>	<u>% Silicate In Solution After Test</u>
15 1	None	60.2
20 2	Sodium diethylenetriamine pentakis (methylene phosphonate) (900)	100
25 3	Phosphino polycarboxylic acid [M.W. = 350] (5000)	100
30 4	Phosphino polycarboxylic acid [M.W. = 1200] (3000)	100
35 5	Sodium polyacrylate [M.W. = 5100] (2000)	100

35 As illustrated in Table I, the antifreeze concentrate formulation of Example 1 retained only 60.2% of the original silicate corrosion inhibitor in solution after dilution with hard water of about 250 ppm as CaCO<sub>3</sub> Total Hardness. However, the stabilized antifreeze concentrate formulations of the instant invention, as exemplified by Examples 2-5, retained 100% of the original silicate corrosion inhibitor in solution after dilution with the same hard water. Examples 2-5 thus indicate the superiority of the antifreeze concentrate formulations of the instant invention in terms of their resistance to alkali earth metal silicate floc precipitation after dilution with hard water.

40 Examples 6-9 were tested for their stability after dilution with hard water by employing Hard Water Test B, described as follows: 30g of the antifreeze concentrate to be tested with mixed with 60 ml of hard water of about 500 ppm as CaCO<sub>3</sub> Total Hardness. This mixture was stored at ambient temperature for 24 hours, then examined for precipitate. If any precipitate was observed, it was removed by filtration. A sample of the filtered coolant and a preliminary sample of the coolant obtained prior to the test were both submitted for  
45 atomic absorption analysis to determine the percentage of silicate left in solution after the test was completed. Table II sets forth the results of Hard Water Compatibility Test B for Examples 6-9.

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TABLE II

## RESULTS OF HARD WATER COMPATIBILITY TEST B

10	<u>Example</u>	<u>Stabilizer Additive (ppm)</u>	<u>% Silicate In Solution After Test</u>
	6	None	44; 51
15	7	Sodium diethylenetriamine pentakis (methylene phosphonate) (100)	48; 68
20	8	Sodium diethylenetriamine pentakis (methylene phosphonate) (100); Sodium polyacrylate [M.W. = 5100] (50)	77
25			
30	9	Sodium diethylenetriamine pentakis (methylene phosphonate) (100); Sodium polyacrylate [M.W. = 5100] (100)	99
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As illustrated by Table II, the antifreeze concentrate of Example 6 retained a maximum of only 51% of the original silicate corrosion inhibitor in solution after dilution with hard water of about 500 ppm as CaCO<sub>3</sub> total hardness. Examples 7 and 8 showed moderate improvement in the percentage of silicate retained in solution. Example 9 retained 99% of the original silicate corrosion inhibitor in solution after dilution with the same hard water. Examples 7-9 thus indicate the superiority of the antifreeze concentrate formulations of the instant invention in terms of their resistance to alkali earth metal silicate floc precipitation after dilution with hard water. In particular, Example 9 demonstrates that a mixture of relatively small concentrations (100 ppm) of sodium aminophosphonate and sodium polyacrylate stabilizers, when added to an antifreeze concentrate containing alkali metal borate and silicate corrosion inhibitors, will effectively prevent alkali earth metal silicate precipitation where said antifreeze concentrate is diluted with hard water.

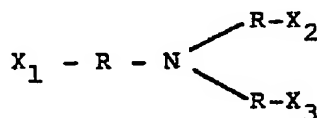
Note that in the above described examples of the instant invention, the presence of additional corrosion inhibitors such as sodium hydroxide, sodium benzoate, sodium molybdate, tolyltriazole, and sodium mercaptobenzothiazole did not inhibit the stabilizing effect of the aminophosphonic acid/aminophosphonate, phosphino polycarboxylic acid/polycarboxylate, or polyacrylic acid/polyacrylate stabilizers in the hard water-diluted antifreeze/coolant compositions.

It will be evident that the terms and expressions employed herein are used as terms of description and not of limitation. There is no intention, in the use of these descriptive terms and expressions, of excluding equivalents of the features described and it is recognized that various modifications are possible within the scope of the invention claimed.

# Claims

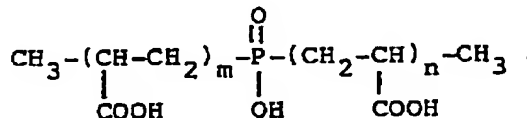
1. An anti-freeze concentrate composition comprising, a water soluble liquid alcohol freezing point depressant, an alkali metal borate corrosion inhibitor and an alkali metal silicate corrosion inhibitor, characterized in that the composition contains from 80 to 99 weight percent of the freezing point depressant, from 0.1 to 10 weight percent of the alkali metal borate corrosion inhibitor, 0.1 to 1 weight percent of the alkali metal silicate corrosion inhibitor and from 100 to 10,000 ppm of at least one precipitation-inhibiting stabilizer consisting of;

(i) a hydrocarbyl aminophosphonic acid and/or alkali metal aminophosphate salt or a mixture thereof, having the formula



where R is a substituted or unsubstituted alkylene radical having up to 12 carbon atoms,  $X_1$  is a hydrogen atom or a hydroxyl, amino,  $-PO(OH)_2$  or  $-N[R-PO(OH)_2]$  group, and  $X_2$  and  $X_3$  are  $-PI(OH)_2$  or  $-N[R-PO(OH)_2]$  groups;

(ii) a phosphino polycarboxylic acid and/or alkali metal phosphino polycarboxylate salt or a mixture thereof, having the formula



where  $m+n$  has a value from 2 to 20 and the molecular weight lies in the range 200-2000; and

(iii) a polyacrylic acid and/or alkali metal polyacrylate salt or a mixture thereof, the polyacrylic acid having a molecular weight in the range 1000 to 10,000.

2. An anti-freeze concentrate composition according to Claim 1, characterized in that the precipitation-inhibiting stabilizer is diethylenetriamine pentakis(methylenephosphonic acid); ethylenediamine tetra(methylenephosphonic acid); N-(hydroxyethyl)-N-bis(methylenephosphonic acid); hexamethylenediamine-N,N,N',N'-tetra(methylenephosphonic acid); or nitrilo tris(methylenephosphonic acid) at a concentration from 100 to 5000 ppm.

3. An anti-freeze concentrate composition according to Claims 1 or 2, characterized in that the precipitation-inhibiting stabilizer is a sodium aminophosphonate at a concentration from 100 to 5000 ppm.

4. An anti-freeze concentrate composition according to Claims 3 & 4, characterized in that the precipitation-inhibiting stabilizer is sodium diethylenetriamine pentakis(methylenephosphonate); sodium ethylenediamine tetra(methylenephosphonate); sodium N-(hydroxyethyl)-N-bis(methylenephosphonate); sodium hexamethylenediamine-N,N,N',N'-tetra(methylenephosphonate); or sodium nitrilo tris(methylenephosphonate).

5. An anti-freeze concentrate composition according to Claim 1, characterized in that the precipitation-inhibiting stabilizer is a phosphino polycarboxylic acid or an alkali metal phosphino polycarboxylate having a molecular weight in the range 300 to 1500, having  $m+n$  in the range 4 to 16 and at a concentration from 100 to 5000 ppm.

6. An anti-freeze concentrate composition according to Claim 1, characterized in that the precipitation-inhibiting stabilizer is a polyacrylic acid or a sodium polyacrylate having a molecular weight in the range 500 to 6000 and at a concentration from 100 to 5000 ppm.

7. The anti-freeze concentrate composition according to any of the preceding Claims, characterized in that the concentrate contains from 0.1 to 0.3 weight percent of a hydrocarbyl azole corrosion inhibitor.

8. The anti-freeze concentrate composition according to any of the preceding Claims, characterized in that the concentrate contains from 0.1 to 5 weight percent of an alkali metal hydroxide, benzoate, nitrate, nitrite and/or molybdate as an additional corrosion inhibitor.

9. The anti-freeze concentrate composition according to any of the preceding Claims, characterized in that the concentrate contains from 0.01 to 1 weight percent of an organosilane silicate stabilizer.

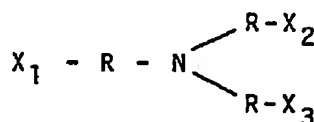
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10. The anti-freeze concentrate composition according to any of the preceding Claims, characterized in that the alkali metal borate corrosion inhibitor is sodium metaborate pentahydrate at a concentration from 0.5 to 5 weight percent.

11. The anti-freeze concentrate composition according to any of the preceding Claims, characterized in that the alkali metal borate corrosion inhibitor is sodium metasilicate pentahydrate at a concentration from 0.15 to 0.5 weight percent.

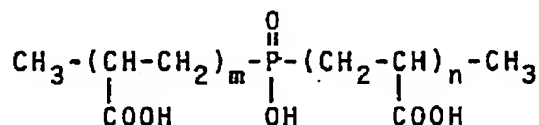
12. A method of treating anti-freeze concentrate compositions containing a water soluble liquid alcohol freezing point depressant, an alkali metal borate corrosion inhibitor and an alkali metal silicate corrosion inhibitor, to reduce precipitation when mixed with hard water, characterized in that from 80 to 99 weight percent of the freezing point depressant, from 0.1 to 10 weight percent of the alkali metal borate corrosion inhibitor, 0.1 to 1 weight percent of the alkali metal silicate corrosion inhibitor and from 100 to 10,000 ppm of at least one precipitation-inhibiting stabilizer consisting of;

(i) a hydrocarbyl aminophosphonic acid and/or alkali metal aminophosphate salt or a mixture thereof, having the formula



where R is a substituted or unsubstituted alkylene radical having up to 12 carbon atoms,  $X_1$  is a hydrogen atom or a hydroxyl, amino,  $-PO(OH)_2$  or  $-N[R-PO(OH)_2]_2$  group, and  $X_2$  and  $X_3$  are  $-PO(OH)_2$  or  $-N[R-PO(OH)_2]_2$  groups;

(ii) a phosphino polycarboxylic acid and/or alkali metal phosphino polycarboxylate salt or a mixture thereof, having the formula



where  $m + n$  has a value from 2 to 20 and the molecular weight lies in the range 200-2000; and

(iii) a polyacrylic acid and/or alkali metal polyacrylate salt or a mixture thereof, the polyacrylic acid having a molecular weight in the range 1000 to 10,000, are incorporated into the composition.

(19)



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(54) **Stabilized antifreeze/coolant composition containing borate and silicate corrosion inhibitors.**

(57) A corrosion-inhibited and stabilized liquid alcohol antifreeze/coolant composition comprising alkali metal borate and alkali metal silicate corrosion inhibitors and at least one precipitation-inhibiting stabilizer selected from the group consisting of: hydrocarbyl aminophosphonic acids, phosphino polycarboxylic acids, polyacrylic acids, and/or the alkali metal salts thereof is described. Ordinarily, insoluble alkali earth metal silicate precipitates detrimental to engine cooling systems tend to form when antifreeze/coolant formulations containing alkali metal borate and silicate corrosion inhibiting compounds are diluted with hard water. However, the stabilized antifreeze/coolant composition of the instant invention resists and inhibits the formation of such insoluble precipitates when diluted with hard water.

EP 0 245 557 A3

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**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.
- namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

**X LACK OF UNITY OF INVENTION**

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

1. Claims 1 (partially), 2, 3, 4, 7-12 (all partially):  
Anti-freeze concentrate composition containing as precipitation-inhibiting stabilizer, a compound of the structure according to claim 1, under i and a method of incorporation these compounds into an anti-freeze concentrate composition
2. Claims 1 (partially), 5, 7-12 (all partially):  
Anti-freeze concentrate composition containing as precipitation-inhibiting stabilizer, a compound of the structure according to claim 1, under ii and a method of incorporation these compounds into an anti-freeze concentrate composition
3. Claims 1 (partially), 6, 7-12 (all partially):  
Anti-freeze concentrate composition containing as precipitation-inhibiting stabilizer, a polyacrylic acid (M = 1000-10000), an alkali metal salt thereof or a mixture of these polymers and a method of incorporation these compounds into an anti-freeze concentrate composition

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.
- namely claims:
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.
- namely claims:

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